Space Weather Technical Forecast

Issued on Saturday, 18 February 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1 Minor Storms possible due to CMEs arrival Day 1 (18 Feb) and likely again Day 3 (20 Feb). M-class flares likely, with slight chance X-class flares throughout (R1-R3 Radio Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity is currently High with a long period X2.28 flare, the strongest of the solar cycle so far, peaking at 17/2016 UTC from AR3229 in the northeast. This region is gradually rotating into view, and appears to have some twisting in its magnetic field lines. Further complexity may become apparent as it becomes more clearly visible. There are a total of seven sunspot regions on the visible solar disc. The largest AR3226 has shown a little more magnetic complexity, but remains inactive. The other regions are generally mature and either stable or declining. A very fast CME emerged in association with the X-flare. The majority of this material was observed to be directed eastwards from the sun away from Earth, a halo shock is showing in coronagraph imagery and the CME has been assessed and there is an Earth directed component. This is predicted to impact on Day 3 (20 Feb).

Solar Wind / Geomagnetic Activity: Solar winds as measured by DSCOVR at L1, continue to be indicative of a High Speed Stream (HSS), likely from the partially obscured positive coronal hole 76. Solar winds remained slightly elevated, declining from 490 and 440 km/s, with density near or slightly below average. The total IMF strength, Bt, remained at Weak levels ranging mostly from 3-6 nT. The north-south component, Bz, varied weakly between +5/-5nT. The associated solar winds Phi angle was positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 has been at background levels throughout. The associated 24 hour electron fluence has been below the Active (1e8 integrated pfu) threshold, reaching 2.68e6 integrated pfu at 18/0000 UTC on a fairly level trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely, with a slight chance of remaining High. The main risk for further significant flaring is AR3229 on the northeast limb.

Solar Wind / Geomagnetic Activity: A CME from 15 Feb is now delayed and was forecast to arrive at 17/1800 UTC +/- 12 hours. This carried moderate confidence at best, and may still arrive in the next few hours. A fast CME from 16 Feb, has some potential for a glancing impact later on 18 Feb. The recent CME associated with the X2.2 flare from 17 Feb has been assessed and there is an Earth directed component. This is predicted to impact on Day 3 (20 Feb). Current slightly elevated solar winds are due to a coronal hole fast wind and may be prolonged through Day 1 (18 Feb) by the CME arrival, before easing during Day 2 (19 Feb). Solar winds may then

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become elevated, possibly Strong for a spell on the 20 Feb, as the CME arrives. Geomagnetic activity starting Quiet, becoming Active to G1 Minor Storm (Kp4-5) with any CMEs arrival in the next few hours, before gradually easing Day 2. During Day 3 (20 Feb) geomagnetic activity is likely to become Active to G1 Minor Storm (Kp4-5) with a Chance of G2 Moderate Storms (Kp6) affecting Earth.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of exceeding S1 in response to larger flares. High energy (greater than 2 MeV) electron flux may increase later in the forecast period, but with low confidence due to potential CME arrivals. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu), but perhaps rising later in the period.

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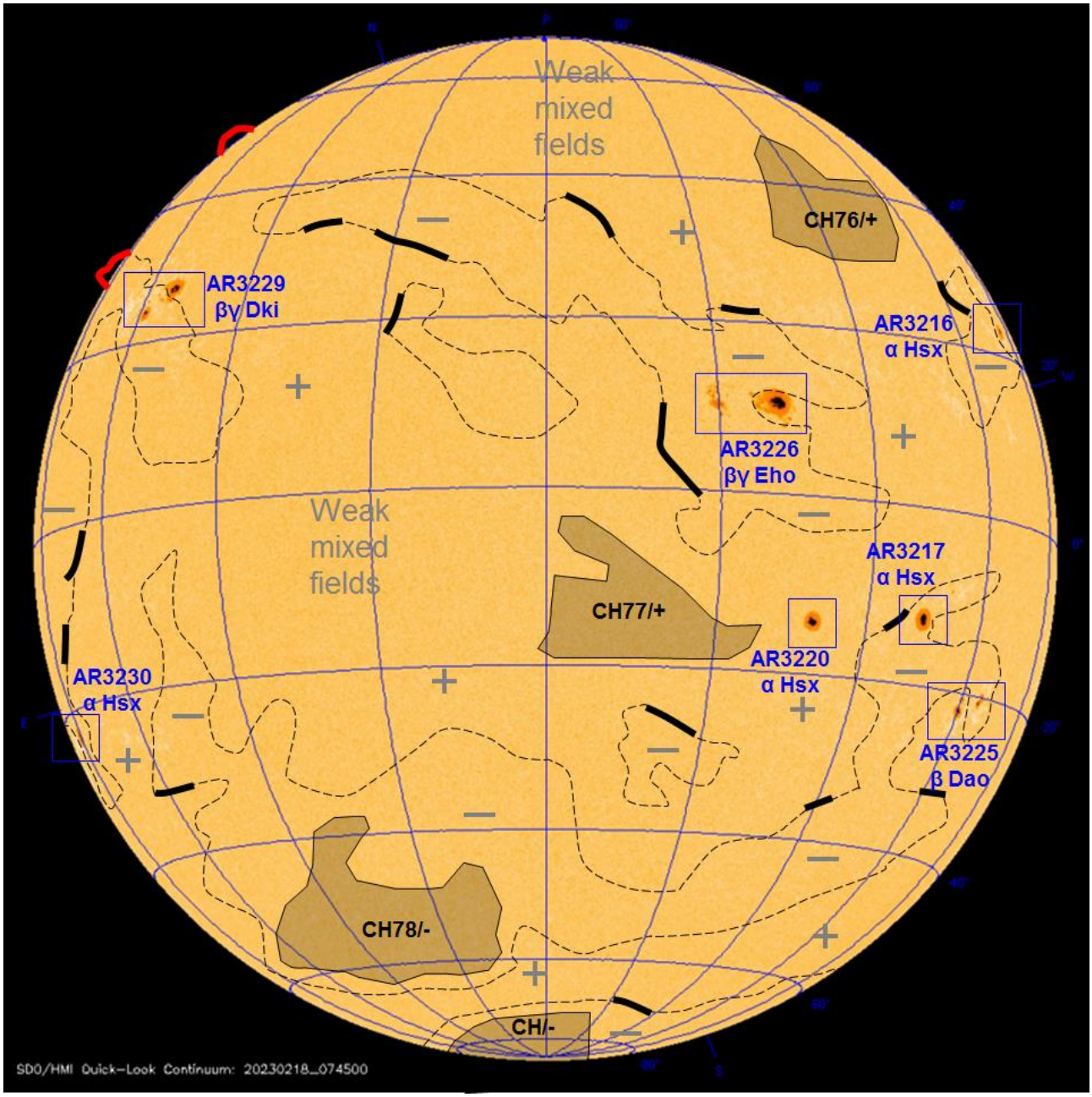
Figure 1. Solar Analysis Valid 0800UTC, 18 February 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from a filament eruption, just east of the central solar disc was forecast to arrive at 17/1800 UTC +/- 12 hours. This timing of the arrival carried moderate confidence at best due to limited available imagery for analysis, resulting in a wide range of potential CME speeds. A fast CME from a filament eruption and associated C9 flare off the northwest disc (near AR3216) on the 16th, has some potential for a glancing impact later on Day 1 (18 Feb). This could combine with, or be indistinguishable from any previous CME influence, but may increase geomagnetic activity. The significant CME on 17 Feb associated with the X2 flare from AR3229 has been assessed. The majority of the ejecta is directed away from Earth, towards the east, however a halo shock is showing in coronagraph imagery which suggests there may be some Earth directed component. This is predicted to impact Earth on Day 3 (20 Feb).
Current slightly elevated have resulted from the High Speed Stream (HSS) originating from a partially obscured coronal hole (CH76) located on the northwest on the visible solar disc. Any CME arrival will likely prolong slightly elevated or perhaps elevated wind speeds through Day 1 (18 Feb), before any CME and CH combined influence starts to ease during Day 2 (19 Feb). Arrival of the CME from the 17th, may result in elevated winds or perhaps even strong solar winds for a time on Day 3 (20 Feb).
Geomagnetic activity starting Quiet, becoming Active to G1 Minor Storm (Kp4-5) with any CMEs arrival in the next few hours, before gradually easing Day 2. During Day 3 (20 Feb) geomagnetic activity is likely to become Active to G1 Minor Storm (Kp4-5) with a Chance of G2 Moderate Storms (Kp6) affecting Earth.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	60	20
Strong	G3	No	1	1	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0815	Partial	Filament	SE	650 km/s	17/1800 +/- 12hrs	Moderate confidence for timing
16/1250	Partial	Filament	NW	1700 km/s	18/0300 +/- 9hrs	Low confidence
18/0239	Full	AR3229	NE	600-1000 km/s	200900 +6/- 12hrs	Moderate confidence

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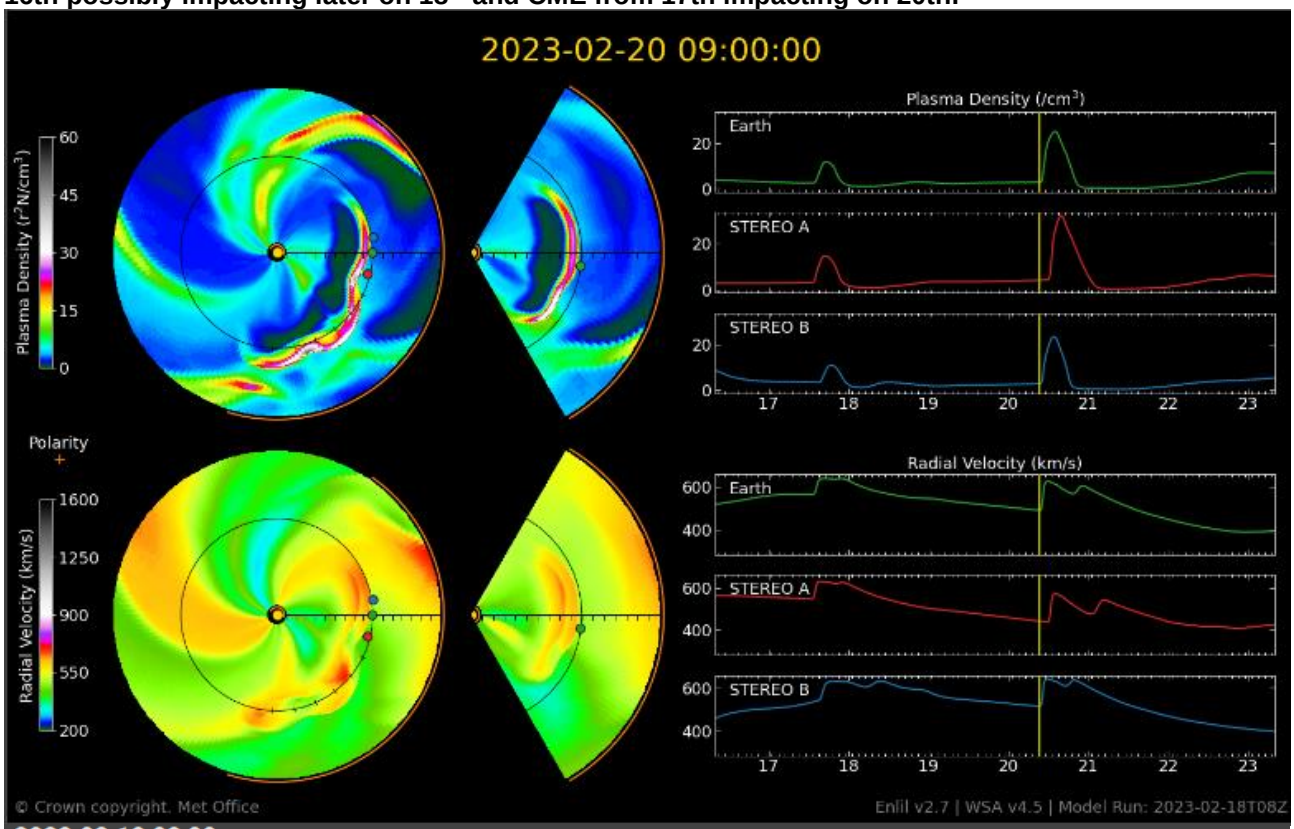
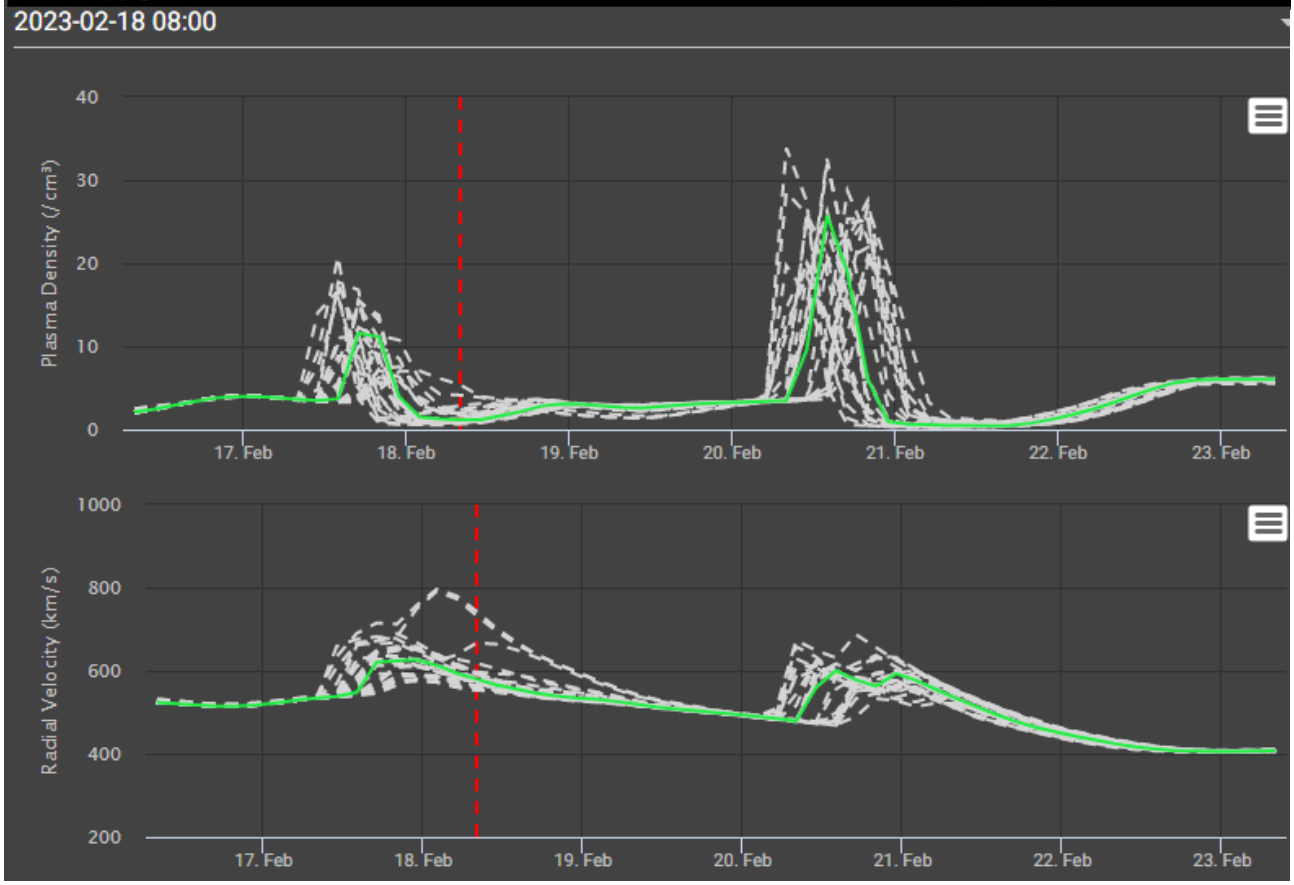
Figure 2: MOSWOC Enlil and ensemble products, showing CME from 15th (overdue), then CME from 16th possibly impacting later on 18th and CME from 17th impacting on 20th.





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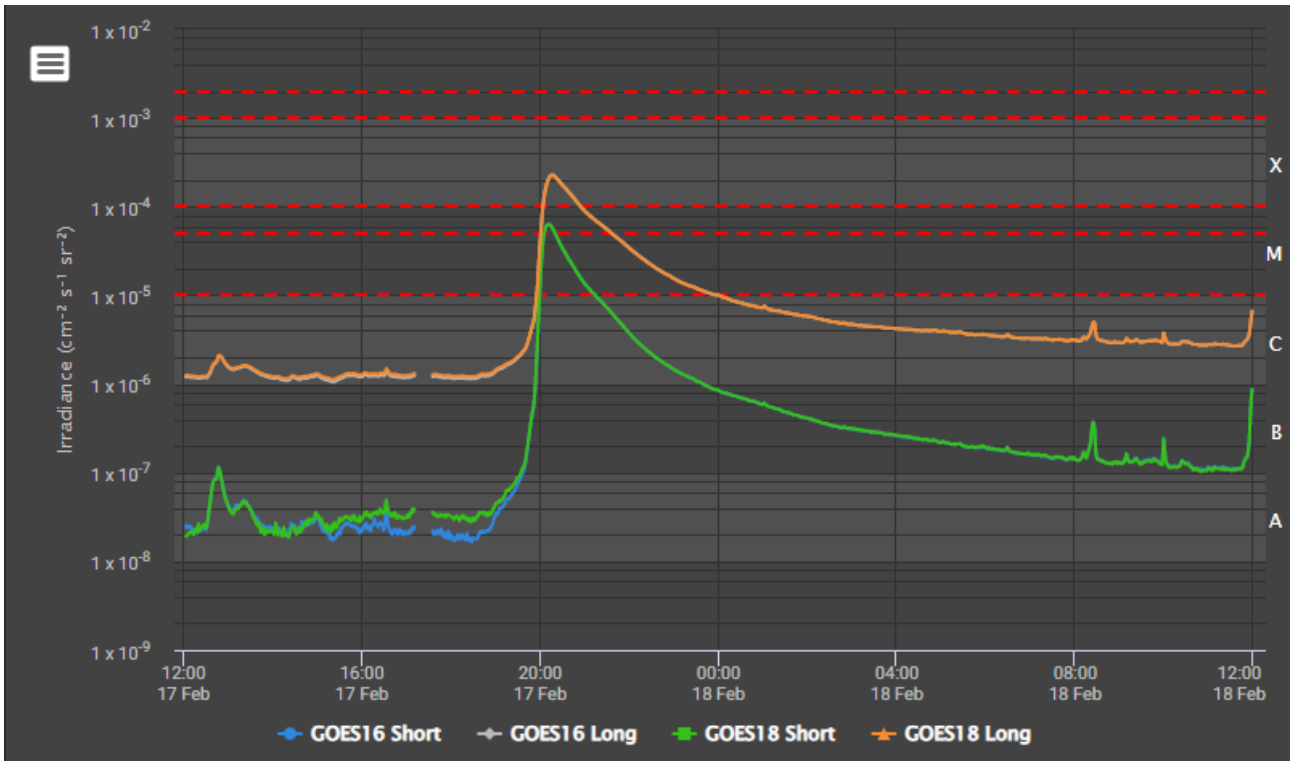
Radio Blackouts - X-Ray Flares:
Solar activity is High with an X2.2 flare peaking at 17/2016 UTC from AR3229, and flare probabilities have been raised higher than raw probs with an M-class flare considered likely and a slight chance of an X-class flare. Activity is likely to be Moderate, with a slight chance of remaining High into Day 2 (19 Feb). There are seven numbered active regions on the visible disc. AR3229 on the northeast limb is the second largest with evidence of magnetic complexity and a north-south alignment, which increases magnetic shear. AR3226 remains the largest and appears mature and largely inactive. AR3225 is a small bipolar region with some development of the intermediate spots. The remaining regions are either stable, simple or benign

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	40	40
Very Active	R3 to R5 X Class	Yes	15	15	10	10

Figure 3: X-ray flux at GEO from GOES showing X2.2 flare on 17 Feb.



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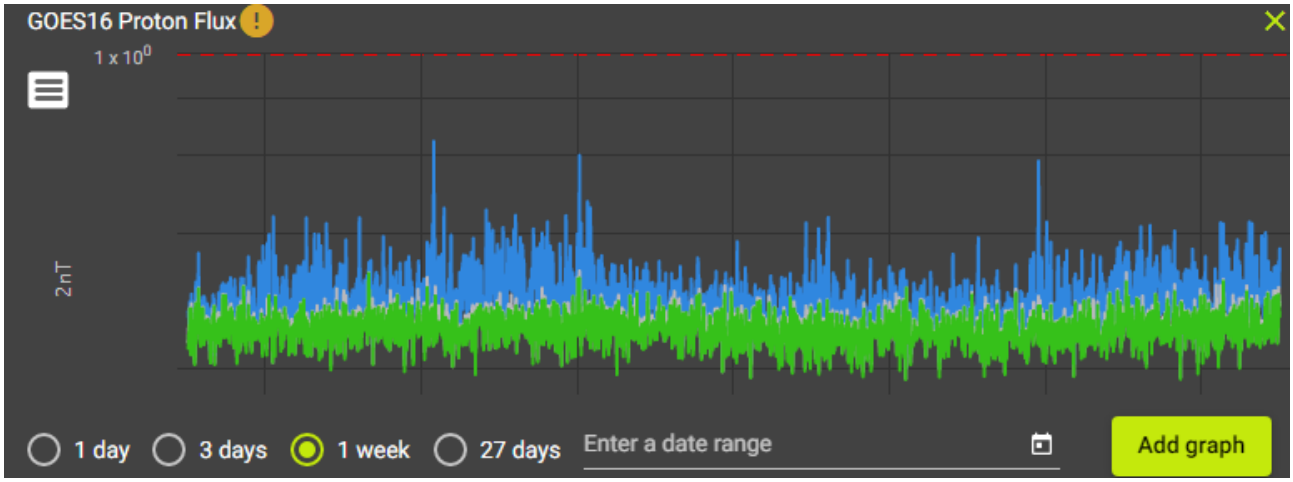
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. The recent X2 flare from AR3229 may increase proton counts, although its location in the eastern hemisphere of the Sun means it is not strongly favoured for connecting to Earth. As such, there is a slight chance of seeing an S1/Minor Storm on Day 1(18 Feb), reducing slightly through Day 2 (19 Feb) unless further large flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: GOES 16 Proton Flux showing no response so far from the X2.2 flare on 17 Feb.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES-16 is currently at background levels, however the recent fast wind enhancement, along with CME arrivals on previous days, has likely increased count rates at lower orbits. As elevated solar winds decline these increased rates have the potential to expand towards GEO. However, any observed increase in flux is expected to become limited by the forecast CME arrival during Day 1 (18 Feb), with further CME or HSS effects possible through the following days. This could potentially result in a drop out of observed flux with any subsequent recovery difficult to predict at this stage. An increase in flux is possible later in the period, but with very low confidence.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above, mainly later in the period. REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output with little change likely in coming days.

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